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PHYSICS.—*Length standards and measurements.*[1] LOUIS A. FISCHER, Bureau of Standards.

Cognizant of the fact that my election to the presidency of the Philosophical Society a year ago, obligated me to give an address of some sort one year later, I confidently waited for the inspiration that I felt would suggest a fitting subject for the occasion. The expected inspiration did not, however, materialize, and when I was finally compelled a few weeks ago to select a subject, I naturally selected the subject which is announced on your program because that is the one with which I am most familiar.

While many attempts have been made to trace the origin of our earlier standards of length, and volumes have been written upon the subject, I think it may be said that very little is known about the subject, which for that very reason lends itself to speculation. The Book of Genesis mentions the cubit as being in use before the Flood; and in the early history of Egypt we find mention of two different cubits which appear to have been in use. The question as to the values of these standards at one time engaged the attention of no less a personage than Sir Isaac Newton, who in a dissertation on cubits gave it as his opinion that the longer of the Egyptian cubits was equal to 20.7 English inches and that the sacred cubit of the Jews was equal to 24.7 inches.

[1] Presidential address before the Philosophical Society of Washington on January 16, 1915.

Later writers attempt to prove by the measurement made of squared slabs of stone used in the buildings of Babylon that the cubit of 20.7 inches was used in their construction, but a little reflection will serve to show the improbability of our being able to derive the length of any standard to a tenth of an inch from such crude data.

Even when we come to our own yard, which is the earliest standard of length now in use, we are in doubt. King Eadgar is recorded to have decreed with the consent of his Wites or council that "the gird or yard kept at Winchester shall be the standard" but all that can really be said as to the origin of the yard is that it was probably brought over to England by the Saxons.

When we consider the crude means which existed for the construction and preservation of standards and the lack of facilities for constructing accurate copies of them, there is little wonder that their original values should be in doubt. There can be no question but that the unavoidable diversity which must have existed in the standards for the measurement of exchangeable commodities in the early organization of civilized society was a serious embarrassment to commerce. The necessity for standards of reference for purposes of barter was no doubt very soon felt by primitive man; and later on when the commercial idea became developed, the need of such standards was greatly increased. As social and political institutions became more fully developed, the values of the units of these primitive systems not only changed but also the relations of the units, until, at the present time, there is no reason to believe that there survives in any existing system of weights and measures a single value of any unit identical with one in use two thousand years ago. As a matter of fact, it is impossible to trace back with any degree of certainty any of the standards, which are now in use, for even a few hundred years.

In England the first attempts at scientific accuracy in matters of measurement date from the beginning of the seventeenth century when John Greaves, one of the earliest scientific metrologists, called attention to the difference between the Roman and

the English foot. He was followed by Edward Bernard, who, in 1685, wrote a treatise on ancient weights and measures; towards the end of the century the measurement of the length of a degree by Picard and Cassini awakened the attention of the French to the importance of rigorously exact standards of length. In considering the development of length standards, we may safely confine our attention to the English yard, the French toise and the meter, since during the last two hundred years they are almost the only standards that have been of any interest to scientific men.

The present English measures of length, as I said before, are supposed to have come down from the Saxons, but the oldest existing standards are the exchequer yards of Henry VII (1490) and Elizabeth (1588). Both are brass end measures, very coarsely made and rudely divided into inches and sixteenths of a yard. Bailey, speaking of one of them in 1836, said that "a common kitchen poker filed at the ends in the rudest manner by the most bungling workman would make as good a standard. It has been broken asunder, and the two pieces have been dovetailed together, but so badly that the joint is nearly as loose as that of a pair of tongs. The date of this fracture I could not ascertain, it having occurred beyond the memory or knowledge of any of the officers at the Exchequer. And yet, within the last ten years, to the disgrace of this country, copies of this measure have been circulated all over Europe and America with a parchment document accompanying them (charged with a stamp that cost £3, 10*s*, exclusive of official fees) certifying that they are true copies of the English *Standard.*"

In the year 1742, certain members of the Royal Society of London and the Royal Academy of Sciences of Paris proposed that, in order to facilitate a comparison of the scientific operations carried on in the two countries, accurate standards of the measures and weights of both should be prepared and preserved in the archives of each of these societies. This proposition having been approved, two substantial brass rods were made at the instance of the Royal Society, and upon them three English feet were laid off with the greatest care. These two rods,

together with a set of Troy weights, were then sent over to the Paris Academy, which body, in a like manner, had the measures of a French half toise laid off upon the rods, and keeping one as previously agreed upon, returned the other, with a standard weight of two marcs to the Royal Society. This, I believe, is the first recorded instance where the standards of two independent nations were compared with one another.

In the year 1758 the House of Commons appointed a committee to inquire into the original standards of weights and measures of England; under instructions from that committee, two brass rods were prepared by the celebrated instrument maker, John Bird, respecting which the committee reports as follows:

> And having these rods, together with that of the Royal Society laid in the same place, at the Exchequer, all night with the standards of length kept there, to prevent the variation which the difference in temperature might make upon them, they were all the next morning compared by means of beam compasses and found to agree as near as it was possible.

The committee recommended that one of these standards should be made the legal standard of England, but this was not done. Instead, on December 1 of the same year, Parliament created another committee on weights and measures, which, in April, 1759, repeated the recommendation that the standard made by Bird in 1758 should be legalized, and further recommended that a copy of it should be made and deposited in some public office, to be used only on special occasions. The copy was made in 1760, but no legislation followed for sixty-four years. When in 1824, Parliament at length took final action, Bird's standard of 1760 was adopted instead of that of 1758. This bar had been generally accepted as the standard for many years by English metrologists and copies of it had been widely circulated. One of these, an 82-inch scale made by the celebrated instrument maker, Troughton, of London, was obtained by Ferdinand Hassler of whom I shall have more to say later, and the distance between the 27th and 63d inches of that bar, which

was supposed to be equal to Bird's yard, served as the standard for the United States until 1856.

On October 16, 1834 the Imperial standard (Bird's standard of 1760) was destroyed by the burning of the House of Parliament, and very soon thereafter steps were taken to recover its length; but it was not until 1855 that the new Imperial standards were completed and accepted by Parliament.

Turning now to the French standards of length, there is evidence that the earliest of these, the Toise of Paris, goes back to the time of Charlemagne (742–814). It is stated that:

> in 1668 the ancient toise was reformed by shortening it five lines (about one-half inch), but whether this reformation was an arbitrary change, or merely a change to remedy the effects of long use, is not known. The old bar was made of iron with the two ends turned up at right angles so as to form a matrix, and the testing of end measures was effected by fitting them between the bent ends. Being placed on the outside of some public building, it was exposed to wear from constant use, to rust, and even to intentional injury by malicious persons.

The earliest use of the toise for scientific purposes was by Picard and Cassini in their measurement of a degree of the meridian passing through Paris. This toise was made in 1668 and would, no doubt, have become the scientific standard of France if it had not disappeared. The second toise used for scientific purposes was one used in the measurement of the Peruvian Arc. This bar, which is known as the Toise du Perou and made in 1735, was made the legal standard of France by an order of Louis XV, dated May 16, 1766, and is still preserved at the Observatoire at Paris.

As is well known, the meter was intended to be equal to the ten millionth part of the quadrant of the terrestrial meridian; but that the measurements of the arc upon which it was based were referred to the toise is a fact of less common knowledge. The measurement of the meridian was entrusted to Mechain and Delambre by the French Academy of Sciences, who carried it on during seven years from 1791 to 1798. The unit of length used by them was the Toise du Perou, and from the arc of 9°40′45″ actually measured, they inferred the length of an arc of the

meridian extending from the equator to the pole to be 5,130,740 toises, from which it followed that the meter was slightly greater than the one-half toise or 0.513074 toise.

The actual construction of the new standards of length was immediately begun. At first four brass end standard meters were made, each very nearly equal to the computed length of the meter. Then the bar which was found after several comparisons to be nearest to the required length, was selected as the provisional standard. Finally two platinum meters and twelve iron meters were constructed and compared with the provisional meter and with one another by means of a comparing apparatus which was capable of showing differences of 0.001 mm. Also, the rates of expansion of all the meters were carefully determined between 0° and 32°C. The comparisons and adjustments of the several meters were continued until no difference amounting to more than 0.001 mm. could be found at the temperature of melting ice. They were all consequently declared to be exact, and one of the platinum meters, subsequently known as the meter des Archives, from its place of deposit, was reserved as the new prototype measure of length.

The other platinum meter was deposited at the observatory at Paris, while the iron meters were distributed amongst the countries which had coöperated with France in this work.

One of these iron bars was brought to the United States by Ferdinand R. Hassler, who afterwards organized the U. S. Coast Survey, or as it is now known, the Coast and Geodetic Survey.

I am not familiar with what Hassler's purpose was in coming to the United States, but it hardly seems possible that he should have brought with him the standard of length upon which was based all the early work done by the Survey, unless he had in mind the organization of that service, and yet the fact that he presented this standard to the American Philosophical Society of Philadelphia shortly after his arrival contradicts this view. When Hassler was placed in charge of the Coast Survey, he secured the bar from the Philosophical Society and it remained in the possession of the Coast Survey until the organization of the

Bureau of Standards in 1901. The bar is made of iron, with a cross-section of 9 by 29 mm. and its length is defined by the end surfaces, which are remarkably plane when one considers the age in which the bars were made. The bar bears the stamp of the committee, which had charge of its construction, namely, a small ellipse, whereof three quadrants are shaded and the fourth one clear, except for the number 10,000,000, which indicates the number of meters in the length of a quadrant of the earth. It also bears certain prick points which distinguish it from the other meters made at the same time. In Mr. Hassler's report on the construction of these meters, it is stated, on the authority of Mr. Tralle, a member of the committee, from whom the bar was obtained, that all the meters agreed with the true meter within one-millionth part of the toise which is about one-half the accuracy claimed by the committee.

This bar, which is known as the Committee Meter, served without interruption as the standard to which all scientific work done in the United States was referred from about 1807 to 1893, a period of about 86 years, when it was superseded by the present platinum-iridium line standard in the custody of the Bureau of Standards. The new platinum-iridium meter not only superseded the Committee Meter, but it also superseded the British yard, inasmuch as in 1893 the yard was defined in terms of the meter, according to the ratio: one yard equals 3600/3937 meter.

In the early development of standards of length, the geodesist has played an important part and the reason for this is at once apparent. His subject is the study of the size and form of the Earth and, in order to make any progress, work has to be done in different parts of his field. If arcs are measured in Europe, Asia, or America, the length of the standards in which they are expressed must be known before any deductions can be drawn from them. In Prussia it is Bessel in 1823, who had a copy of the Toise of Perou constructed by Fortin of Paris, in order that he might express the results of his determinations of the length of his seconds pendulum at Koenigsberg in terms of what was then the generally accepted standard for geodetic work. The Toise of Bessel was later to take an important part in the history

of geodesy for the reason that it became the point of departure of a large part of the triangulation made in Europe in the nineteenth century. Again it was the International Geodetic Association composed of delegates from the leading countries of Europe, which, meeting at Berlin in 1867, decided among other things that the interests of science in general and geodesy in particular demanded a uniform decimal system of weights and measures throughout Europe, and recommended the metric system without essential change.

The action of the Geodetic Association was echoed by the St. Petersburg Academy of Sciences in 1869, which in a communication to the Paris Academy of Sciences suggested that common steps be taken towards the establishment of an international metric system. Soon after the matter was brought to the attention of Napoleon III, who approved the idea of an international convention, and the French government extended invitations to the various governments to send delegates to Paris to discuss the construction of a new prototype meter as well as a number of identical standards for distribution to interested nations.

In response to an invitation of the French government, the following countries sent representatives to a conference which met in Paris on August 8, 1870:

AUSTRIA, ECUADOR, FRANCE, GREAT BRITAIN, GREECE, ITALY, NORWAY, PERU, PORTUGAL, RUSSIA, SPAIN, SWITZERLAND, TURKEY, UNITED STATES, COLUMBIA.

At this conference, which was of short duration, on account of the war then raging between France and Germany, the United States was represented by Joseph Henry and J. E. Hilgard, two former members of our Society.

A second conference was held two years later, at which 30 countries were represented, the United States again being among this number. At this conference it was decided that new kilograms as well as new meters should be constructed to conform with the original standards, and a permanent committee was appointed to carry out this decision. The preparation of the new standards had advanced so far by 1875 that the permanent committee appointed by the conference of 1872

requested the French government to call a diplomatic conference at Paris to consider whether the means and appliances for the final verification of the new standards should be provided, with a view to permanence, or whether the work should be regarded as a temporary operation.

In compliance with this request a conference was held in the spring of 1875, at which 19 countries were represented, the United States as usual being of this number, and on May 20, 17 of the 19 countries represented signed a convention which provided for the establishment and maintenance of a permanent International Bureau of Weights and Measures to be situated near Paris and to be under the control of an international committee elected by the conference, the committee to consist of 14 members, all belonging to different countries.

In addition to the primary work of verifying the new metric standards the bureau was charged with certain duties, the following being the most important:

(1) The custody and preservation, when completed, of the international prototypes and auxiliary instruments.

(2) The future periodic comparison of the several national standards with the international prototype.

(3) The comparison of metric standards with standards of other countries.

It was agreed that the expenses of the bureau should be defrayed by contributions of the contracting governments, the amount for each country depending upon the population and upon the extent to which the metric system is in use in any particular country. In accordance with the terms of the convention the French government set aside a plat of ground just outside of Paris, and upon this ground, which was declared to be neutral territory, the International Bureau of Weights and Measures was established.

The construction of the meters was entrusted to a special committee, and early in 1887 the committee completed its work and the new meters were turned over to the international bureau for comparison with the standards of the Archives and with one another.

It had been decided as early as 1873 that the new standards should be made of an alloy of 90 per cent platinum and 10 per cent iridium, and that they should be line standards. Altogether 31 meters and 40 kilograms were constructed. By 1889 the entire work was completed and in September of that year a general conference was held at Paris, and by it the work of the international committee was approved.

The meter and kilogram which agreed most closely with the meter and kilogram of the Archives were declared to be the international meter and the international kilogram. These two standards, with certain other meters and kilograms, were deposited in a vault under one of the buildings of the international bureau, where they are only accessible when three independent officials with different keys are present. The other standards were distributed by lot to the various governments contributing to the support of the international bureau. Those falling to the United States were meters Nos. 21 and 27, and the latter of these two standards, which was accepted as the National Prototype, superseded our earlier standards.

Practically all that has been said heretofore has had reference to standards rather than to measurements made with them. In deciding upon what measurements to select for discussion it appeared to me that none were more interesting than the measurement of base lines. Perhaps my interest in them is due to the fact that I was a witness to very radical changes in the method of making them. When I entered the Coast and Geodetic Survey over 30 years ago my first task was to assist in a very minor capacity in determining the lengths of two base measuring bars of a new design which will be found described in appendix No. 7 of the Report of the Survey for 1882.

These bars were supposed to be compensated for temperature, the metals being two steel bars connected to the opposite ends of a zinc bar in such a manner that the expansion of the two different metals would compensate one another. They were end standards and the method of using them in the field was the well known one of supporting the bars on tripods and placing them end to end. The standard with which they were com-

pared consisted of five separate end meters, each one of which had been carefully compared with the committee meter, the 5 meters being placed end to end on a suitable support and kept in contact by the tension of springs. This apparatus was used to measure the Yolo base in California, the probable error of which was computed to be 1 part in 1,750,000.

The next bars used for this work were what are known as 5-meter contact rods and consisted of a single bar of steel enclosed in closely fitting wooden cases afterwards covered with padded canvas. The temperatures of these bars were determined by means of thermometers in contact with the bars some distance from their ends which were read through windows in the wooden case and convas covering. The method of using these bars in the field was the regular method of mounting them on tripods and placing them end to end. The accuracy of the measurements of this style of bar in the hands of the party in charge of Mr. O. H. Tittmann in 1891, was about 1 part in 1,700,000.[2]

At the same time that this base was measured with bars 13 and 14, apparatus of an entirely new design by Dr. R. S. Woodward was tried out on the same base. This apparatus, which was described by Professor Woodward before this Society some years ago, consists of a 5-meter bar which, in use, is carried in a steel trough and covered with crushed ice, the trough in turn being supported upon two trucks which travel on a portable track. Posts are placed in the ground 5 meters apart and upon them micrometer-microscopes are mounted. The operation of measuring consists in bringing the bar under the first two microscopes and then setting the cross wires of the microscope on the lines of the bar. Then without disturbing the reading of the forward microscope the bar is displaced longitudinally until the line on the rear end of the bar is brought under the forward microscope while at the same time an observer at the forward end of the bar points on the line at that end, this process being repeated until the base is completed. A kilometer measured in this way is estimated by Dr. Woodward to have an accuracy of about 1 part in 3,000,000, but the method is extremely expen-

[2] Appendix No. 8, U. S. Coast and Geodetic Survey Report for 1892.

sive. The other method designed by Professor Woodward consists in measuring the base with 100-meter steel tapes, equipped with special stretching devices and standardized on the kilometer measured in terms of the 5-meter iced bar. Very rapid progress could be made in measuring with these tapes and the preparation of the ground was reduced to a minimum.

The tapes used were ordinary steel tapes and measurements had to be made at night to avoid the direct radiation from the sun; but the results were nevertheless so satisfactory that the method at once attracted attention, the greatest objection to the method was the necessity of carrying the iced bar in the field for the purpose of laying out a hundred meter standard with which the length of the tapes could be frequently checked. While even then the tape method possessed certain obvious advantages the base bar method still had its advocates. After the measurement of the Holton, Md., and St. Albans, W. Va., bases two duplex base bars designed by Wm. Eimbeck were constructed by the Coast and Geodetic Survey and a base line was measured with them near Salt Lake City, Utah, in 1897, with a probable error of 1 part in 800,000.[3] A duplex bar consisted of two concentric brass tubes in the inner of which were mounted a steel and a brass measuring bar. Holes were provided in both the outer and inner tubes for the insertion of thermometers, and the apparatus was so constructed that the inner tube could be rotated 180° and thus equalize the temperature of the brass and steel components if one side of the apparatus should be more exposed to the direct radiation of the sun. Mr. Eimbeck's idea was that if the bars were standardized under a sufficiently wide range of temperature the length of either the brass or steel component could be determined as a function of the difference in the lengths of the bars, and consequently the apparatus itself could serve as a thermometer. Subsequently in measuring a base line the difference in the length of the base as given by the two components would furnish data from which the length of the base could be computed. As a precautionary measure the temperature was observed when standardizing

[3] Appendix 12, Coast and Geodetic Survey Report for 1897.

and using the bars. It is probable that this form of apparatus would have been extensively used and have superseded all other base bars but for the introduction of tapes. In 1900 and 1901 a party of the Survey measured nine base lines along the 98th meridian, using these bars and fifty- and one hundred-meter steel tapes. The tape measures agreed so closely with the bar results that the officials felt justified in discarding bars altogether for base measuring, and in substituting tapes. Mr. A. L. Baldwin who had charge of this campaign of base measurements described his season's operations in an address before this Society. An elaborate report on the work is contained in the 1901 report of the Survey.[4]

But the problem of an entirely satisfactory base measuring apparatus was not solved until the discovery of the nickel-steel alloy called "invar" with very small temperature coefficients. Tapes made of this alloy used during the day and subject to the usual temperature variations, when exposed to the sun's rays, gave better results than the steel tapes used at night, and at a lower cost. All primary bases of the Coast and Geodetic Survey are now measured with invar tapes, and in each of the other countries conducting geodetic surveys the base apparatus, which is nearly always in the form of tapes or wires, is made of invar. A paper was read before this Society by Mr. O. B. French in which he gave the results of various tests of invar tapes made at the Bureau of Standards and in the field during actual measurements.

What, may we inquire, were the industries doing for standards while they were in the hands of the geodesists, and before the establishment of the National Standardizing Laboratories? It would be impossible for one to cover the whole field in the time at my disposal nor do I think the development in the different countries was sufficiently different to require this.

The need of accurate and reproducible standards was nowhere felt sooner in the industries than in the United States,

[4] Other publications of the Survey which give the results of recent measurements of bases are Appendix 5, Report for 1907; Appendix 4, Report for 1910 and Special Publication No. 19.

since this country was the first to specialize in the manufacture of machinery the parts of which are interchangeable. As examples, I need only mention the early manufacturer of watches and sewing machines whose success was absolutely dependent upon the maintenance of one standard throughout their product. That the manufacturer could not go out in the open market and purchase the gauges that were needed is shown by a statement of Prof. W. A. Rogers in 1878, who said:

> I have a large collection of micrometers by different makers, both at home and abroad; I have standards by Froment and Brunner of Paris, and Merz of Munich; I have transfers from every well known precision screw in this country, including such makers as Buff and Berger of Boston; Clark of Cambridge; Brown and Sharpe of Providence; Rutherford of New York; Clement of London; Bianchi, Froment, and Perreaux of Paris. The investigation of these transfers is not yet quite completed, but I feel safe in saying that no two of them agree at a given temperature, and the errors of subdivisions are, in many cases, very large, and in all cases easily measurable. Of the micrometers made abroad, the best I have seen are by Powell and Leland. They are superbly ruled, and the errors of the subdivisions are much less than usual, but in the two plates measured, the unit was found to be nearly 1½ per cent too long.

While anyone comparing the same class of apparatus at the present time would still find differences, they would be of an entirely different order.

Even as late as 1880 the very important relation of the yard to the meter as given by different authorities varied from 39.3697 to 39.3708 or 0.0011 of an inch. This variation was reduced to a little over two ten-thousandths of an inch at this time by Mr. O. H. Tittman,[5] by the apparently simple expedient of referring all the observations to the British Imperial yard and the committee meter at the temperatures at which these bars are standard.

The United States has been fortunate in having two firms who applied themselves to the task of supplying accurate tools and gauges at the time when American industries began to demand them. I refer to the firms of Brown and Sharpe of Providence, R. I., and Pratt and Whitney of Hartford, Conn.,

[5] Appendix No. 16, Coast and Geodetic Survey for 1890.

whose work was so precise that they not only made it possible for American manufacturers to lead in many lines, but they also contributed in no small way to the spreading of uniform manufacturers' standards throughout the world. So accurate is their work that it is very often difficult even with our present facilities to determine with certainty the differences in their product. At the present time steel guages may be obtained that are guaranteed by their maker to be correct to within the 1/100,000 part of an inch, and several sets measured at the Bureau of Standards were certainly correct to within twice this error. Roughly speaking the accuracy in their comparison of length standards is about ten times as great as it was forty years ago. At that period, neither the yard nor the meter could be compared with greater accuracy than one part in 400,000, while at the present time it is no difficult feat to compare them to one part in 5,000,000. The establishment of great national standardizing laboratories with their corps of trained metrologists and special apparatus is largely responsible for this. At the present time practically every country has a laboratory whose facilities are available to the manufacturer, while 40 years ago he could only secure reliable standards with great difficulty and was compelled to devise his own means for duplicating them.

I have said nothing whatever about the determination of the distances between the planets nor of the units used by astronomers in reckoning distances of the stars. Neither have I said anything about the measurement of very small distances or objects by interference methods or by means of the ultraviolet microscope. They form, so to speak, other chapters of the subject which I shall leave to some future ex-president of our Society. I have confined my own discussion to measurements that have been within my own experience. I do not claim to have covered even this range with any completeness; but I have merely attempted to give such facts as would interest you, and in doing this it is possible that I have given more prominence to what has been done in the United States and by members of our Society than is justified by the title of this paper.

GEOLOGY.—*Some features of the ore deposits of Gilpin County, Colorado.*[1] EDSON S. BASTIN and J. M. HILL, U. S. Geological Survey.

Gilpin County and the adjacent portions of Boulder and Clear Creek counties constitute one of the oldest mining districts in Colorado. Central City, the principal mining camp of the region, was the site of the first discovery of lode gold in Colorado, made by John Gregory in the spring of 1859. The period of greatest prosperity in this region was the seventies and eighties, but it has remained an important producer of gold and silver down to the present time, and will doubtless continue so for many years to come. The region lies in the Front Range of the Rocky Mountains, 30 to 40 miles west of Denver. The principal mining centers are Central City, Idaho Springs, Nederland, Alice, and Dumont.

The geologic groundmass of the region consists of pre-Cambrian rocks, both sedimentary and igneous in origin, and in part dynamo-metamorphosed. The pre-Cambrian sediments are mostly argillaceous and the igneous rocks granitic. Into this groundmass Tertiary igneous rocks have been intruded as stocks and dikes. Monzonite is the predominant rock type among these intrusives, but many other rocks have been derived by magmatic differentiation from the monzonite magmas, titaniferous iron ores and porphyry dikes representing the extreme products. The Tertiary intrusives which are the "porphyries" of the miners are (with few exceptions) older than the ores.

The ore deposits may be classified according to the metals which give them their predominant value as follows:

(1) *Gold-silver ores.* This class is the most widespread and most productive and the only one that will be described in detail in this paper.

(2) *Uranium ores.* These are confined to a small area on Quartz Hill near Central City, and are believed to be a phase of the gold-silver ores.

(3) *Tungsten ores.* These were not studied in detail by the

[1] Published with the permission of the Director of the U. S. Geological Survey.

authors. The tungsten district of Boulder County is the principal producing district in the United States.

(4) *Copper ores.* Ores poor in silver and worked primarily for copper occur in one mine, the Evergreen, near Apex. The copper sulphides here are primary constituents of monzonite dikes.

(5) *Titaniferous iron ores.* These are products of magmatic differentiation within the monzonite stock at Caribou. They have no present or prospective commercial value.

Veins are the predominant structural type among the ore deposits. These commonly follow fracture zones rather than single fractures. The longest is the Mammoth vein near Central City which has been traced continuously for 6000 feet. The greatest depth to which a vein has been followed has been 2250 feet. The vein mineralization has been accomplished in part by fissure-filling and in part by replacement, the latter process being in general predominant. In addition to the veins there are in the region a few stockworks, the best known being the so-called "Patch" near Central City, a pipe-shaped mass of brecciated rock formed at a place where a number of strong vein fractures approach unusually close together. The mineralization of the "Patch" is continuous with that of the veins which enter it and is of the same mineral character. Chamber stopes large enough to accommodate a three-story house have been excavated in the "Patch."

Gold-silver ores. These occur mainly as veins with a few stockworks. The main values are in gold and silver; the subsidiary values in copper, lead, or zinc. They may be classed, on the basis of mineral composition, into the pyritic type, galena-sphalerite type, composite type, and the telluride type. The predominant minerals of the pyritic ores are pyrite and quartz; chalcopyrite and tennantite are usually present. They are essentially gold ores. Their usual composition is as follows: Au 1 to 3 ounces; Ag 4 to 8 ounces; Cu commonly less than $1\frac{1}{2}$ per cent, but in some 15 to 16 per cent. Within a small area near Russell Gulch a number of the pyritic veins carry enargite in place of tennantite, and some of the veins in this region also carry fluorite.

The galena-sphalerite type is less widespread than the pyritic. The predominant minerals are galena, sphalerite and a carbonate (usually calcite or siderite); pyrite, chalcopyrite, and quartz are present in lesser amounts. In the region northeast of Idaho Springs a number of the veins of this type carry rhodochrosite. The metal content is more variable than in the pyritic ores, the usual content being as follows: Au 0.1 to 5.5 ounces; Ag 2 to 25 ounces; Cu commonly less than 1½ per cent, rarely exceeds 10 per cent; Pb 0 to 55 per cent; Zn 0 to 25 per cent. The varieties poor in gold have, in many cases, undergone downward enrichment in silver and constitute the typical silver ores of the region. In contrast to these, certain veins, such as the Klondike in the Topeka mine, are very rich in gold. The Klondike locally carried free primary gold in large plates; an 88-pound piece from this mine yielded upon smelting $5,500.

The composite ores are the result of dual mineralization, first with ore of the pyritic type and then, after brecciation, with ore of the galena-sphalerite type. The reverse relation of pyritic ore filling brecciated galena-sphalerite ore was not observed. Certain veins are pyritic at one end, composite in the middle, and of the galena-sphalerite type at the other end. Composite veins are in general most abundant between areas characterized by pyritic ores and areas in which galena-sphalerite ores predominate.

It is believed that the ores of this region are genetically related to the Tertiary igneous rocks. The copper and iron ores, being products of magmatic differentiation, are obviously so related. In the case of the veins, the agent of ore deposition is believed to have been ascending thermal solutions of an alkaline or neutral character. That the composition of these solutions varied in different parts of the region even at the same period is shown by the presence of enargite in a localized group of the pyritic veins, and the presence of rhodochrosite in a localized group of the galena-sphalerite veins. The composition of the solutions also changed progressively during the mineralizing period, the pyritic ores being deposited in the early part of this period and the galena-sphalerite ores at a later time. From the extent

of erosion since the veins were formed it is estimated that they were deposited at depths of from 7000 to 11,000 feet. The temperature of formation can not be accurately determined. A minimum may be placed at 100°C., for this temperature is reached under the "normal" increment of temperature at a depth of about 9000 feet. A maximum may be placed at 575°, for all of the quartz associated with the veins is of the low temperature variety. It is believed that the temperature of formation was probably between 150 and 300°C. The minerals of the veins are those characteristic of moderate depth and pressure.

Downward enrichment. This process has produced important modifications in many of the gold-silver ore deposits. There has been enrichment in one or all of the metals, gold, silver, and copper; enrichment in lead and zinc is insignificant. The water level, as in most mountainous regions, is irregular. In most veins it originally stood 50 to 150 feet below the surface.

Gold enrichment appears to be confined to the oxidized zone and has been accomplished largely by mechanical concentration during weathering. Presumably there was also solution of gold in the oxidized zone, but it is believed that the dissolved gold was promptly reprecipitated within the oxidized zone or immediately below it through the action of primary sulphides or of ferrous sulphate. Careful sampling in a number of the mines failed to show any relation between gold content and depth after the oxidized zone was passed. Gold enrichment in the oxidized zone is most conspicuous in certain so-called silver veins. Where unaltered these carry only about 0.1 of an ounce of gold, but in the oxidized zone this has in some mines been increased to 1.5 or even 3 ounces.

In contrast with gold there has been impoverishment in silver rather than enrichment, in the oxidized zone. The primary silver minerals are silver alloyed with gold, silver-gold tellurides, and possibly argentite. The secondary silver minerals are cerargyrite, pearceite, polybasite, and proustite. The scarcity of silver in the oxidized zone is readily understandable, for it is well known that silver is more readily dissolved than gold and is reprecipitated by fewer of the common sulphides. The silver

carried down below the oxidized zone is probably for the most part in balance with the sulphate radicle SO_4. It is redeposited mainly in the form of silver-arsenic sulphides, as replacements of the primary ore minerals or as fillings of small fissures in the primary ore. The chemistry of the process is not well understood, but observations in this region fix certain limiting conditions. It is noteworthy that in the secondary minerals as in the primary minerals arsenic greatly predominates over antimony. Silver enrichment is practically confined to the veins of the galena-sphalerite type and is absent from those of the pyritic type. The most important cause of this restriction is believed to be the presence of carbonates in the galena-sphalerite veins. These carbonates neutralize the descending oxidizing waters and, in the case of siderite, ferrous sulphate, an active silver precipitant, is generated by reaction with sulphuric acid.

Nishihara[2] has compared the neutralizing effect of various minerals on sulphuric acid and also their efficiency in reducing ferric sulphate to ferrous sulphate. Pyrite, quartz, and chalcopyrite, minerals characteristic of the pyritic type of ores, are ineffective in both respects. Galena, sphalerite, and, of course, the carbonates are effective neutralizers and fairly active in reducing ferric to ferrous sulphate. Moreover, galena and sphalerite in contact with solutions carrying sulphuric acid or ferric sulphate generate hydrogen sulphide. The composition of the galena-sphalerite ores favors, therefore: (a) rapid neutralization; (b) reduction of ferric to ferrous sulphate; (c) generation of ferrous sulphate from siderite; (d) generation of hydrogen sulphide. All these actions are believed to favor the precipitation of silver. The pyritic ores, on the other hand, have a mineral composition which favors persistence of acidity and persistence of the iron in the ferric state. Dissolved silver descending through such ore-bodies is likely to remain in solution, to enter the general groundwater circulation, and to be lost so far as the ore deposits in question are concerned.

[2] Nishihara, G. S., The rate of reduction of acidity of descending waters by certain ore and gangue minerals and its bearing upon secondary sulphide enrichment. Econ. Geol., 9: 743–757. 1914.

BOTANY.—*A new genus, Fortunella, comprising four species of kumquat oranges.* WALTER T. SWINGLE, Bureau of Plant Industry.

The kumquat oranges are of very small size, usually less than an inch in diameter. The two species commonly cultivated differ from other oranges in having a relatively thick, fleshy, sweet and edible peel and in having only 4 to 7 segments, containing a small amount of acid pulp. Besides the round and oval-fruited species common in culture, there is a third species recently introduced into culture from China, and a fourth occurring wild on the Island of Hongkong.

HISTORY OF THE KUMQUAT ORANGES

The kumquat oranges, though described by early Chinese writers on agriculture, remained practically unknown to Europeans until recent times. The kumquat is mentioned in many early Chinese works and described in some detail by Han Yen Chi in his treatise on the oranges; written in 1178. Later works of both Chinese and Japanese authors treat of it fully, often with fairly good illustrations.

The first vague notice of the kumquat oranges in European literature was published by Ferrarius in 1646 in his Hesperides and was based on reports made to him by the Portuguese Jesuit, Alvaro Semedo, who lived 22 years in China. His successors, Steerbeck, Volckamer, Risso and Poiteau, and other authors of monumental illustrated works on the citrous fruits, add nothing to our knowledge of the kumquat.

Rumphius in 1741 described and figured the round kumquat in his Flora Amboinense. This was the first good account of any kumquat orange to appear in European literature. In 1780 Thunberg assigned the name *Citrus japonica* to the round kumquat, and in 1784 described it more fully in his Flora Japonica, still later (in 1800) publishing a fairly good figure of it in his Icones Plantarum Japonicarum. Loureiro, in 1790, in his Flora Cochinchinensis named the oval kumquat *Citrus margarita*, and also described the round kumquat under the name *Citrus madurensis*.

In spite of Rumphius' and Thunberg's excellent description and illustrations, the kumquat was not known in Europe until 1846, when Robert Fortune, who was collecting in China for the Royal Horticultural Society of London, brought back to England the first kumquat plants. The kumquat did not become generally known on the continent of Europe until much later.

Full descriptions of the round and oval kumquats were published by H. H. Hume,[1] but not until 1912 was a good account of these plants published in Europe, when Dr. L. Trabut[2] described them and distinguished them from the so-called "chinois" or "chinotto" (*C. Aurantium* L., var.), with which they had been confused by Volckamer and many subsequent European writers. In 1914 Dr. Trabut[3] published in Algeria a fuller illustrated account of these plants.

Perhaps because of their relatively late advent into Europe the kumquat oranges have been but little studied by botanists. Apparently no one has questioned the judgment of Thunberg in referring them to the genus Citrus.

THE KUMQUATS NOT PROPERLY REFERRED TO THE GENUS CITRUS

The question of the true relationship of the kumquats to other citrous fruits was forced upon the attention of the writer, in the course of a survey of the plants related to Citrus, by a study of a little known plant of Hongkong, called by botanists *Atalantia Hindsii* (Champ.) Oliv. Good herbarium specimens of this plant, collected by the Wilkes North Pacific Exploring Expedition in 1842 and preserved in the National Herbarium at Washington, D. C., showed the unmistakable facies of a kumquat orange. The thick, rigid leaves, pale and abundantly glandular-dotted below, the angular twigs, small flowers, more or less angular

[1] Hume, H. H. The Kumquats. Bull. 65, Fla. Exp. Sta., pp. 550-566, 3 figs. 1903; also, Citrus Fruits and their Culture, 3d ed., p. 18, pp. 53-58, pp. 129-131, *figs. 4, 5, 10, 28.* 1909.

[2] Trabut, L. Chinois et kumquat.• Rev. Hort. **84**: 564-567, *figs. 193-195.* 1912.

[3] Trabut, L. Le kumquat. Bull. Agric. de l'Algerie et de la Tunisie II. **20**: 2-11, *4 figs.* 1914.

in the bud, and the small prominently glandular-dotted fruits all resembled most strikingly the round kumquat now commonly cultivated in this country.

Later on other specimens of this plant were studied in the herbaria at Kew Gardens and the British Museum, London, and the Muséum d'Histoire Naturelle, Paris; and through the courtesy of the Superintendent of the Botanical and Forestry Department of Hongkong viable seeds of this species were sent to the writer in 1912. A study of the germination, as well as of the foliar, flower, and fruit characters, showed that in reality this plant is a very primitive kumquat. Thereupon the various forms of the common kumquat in culture in Florida, California, and Algeria were studied, as well as the material in the principal herbaria of Europe and America. As a result of this study the writer is convinced that the kumquats should be placed in a new genus midway between Atalantia and Citrus.

The kumquats are the most primitive living true citrous fruits. The Hongkong kumquat, the only species known in the wild state, is the most primitive of the kumquats and consequently the most primitive of the true citrous fruits. That is to say, it is of all known existing species the most nearly like the ancestral form from which the kumquats and the species of Citrus originated.

On account of their many and important differences from Atalantia and from Citrus it is proposed to create a new genus, Fortunella,[4] to include the kumquats.

[4] **Fortunella,** Swingle, gen. nov. *Citro* affinis, foliis unifoliolatis, staminum numero petalorum quadruplo. A *Citro* differt floribus solitariis vel in paniculis paucifloribus dispositis, numero loculorum ovarii numero petalorum aequali vel paulo majore, ovulis collateralibus in loculo geminis, stigmate cavernoso ob glandulas oleiferas profundas, foliis venis non prominentibus subtus pallidioribus punctis glandulosis viridibus numerosissimis instructis, alabastro in sectione plus minusve polygono, fructu mesocarpio crassiore, carnoso et eduli. Rami juniores novelli virentes triangulares, vetustiores teretes. Cotyledones in germinatione ut in *Citro* hypogeae, folia prima ovata subsessilia opposita. Frutices vel arbores humiles.—Species typica, **Fortunella margarita** (*Citrus margarita* Lour.). Colitur Cantone Sinarum.

FORTUNELLA Swingle. Shrubs or small trees; young branches angular, the older ones rounded; spines borne singly at one side of the bud in the axil of the leaf, or wanting. Leaves unifoliolate, rather thick, blunt-pointed or even retuse, acute or rounded at the base; veins evident above, scarcely showing beneath; lower surface pale green, densely glandular-dotted; petioles narrowly winged or merely margined, sometimes not articulated with the blade. Flowers borne singly or in few-flowered clusters in the axils of the leaves, hermaphrodite, 5-merous (rarely 4-, 6-, or 7-merous). Flower buds small, 8–10 mm. long, more or less angular in cross section. Petals 5 (rarely 4 or 6), white, acute, 8–12 mm. long. Stamens 18 or 20, polyadelphous, cohering irregularly in bundles; filaments broad but tapering at the tip. Pistil seated on a well-marked disc; ovary subglobose, 3–7-(usually 3–6-)celled, with two collateral ovules in each cell; ovary merging gradually or abruptly into the short style, this usually shorter than the ovary, sometimes shorter than the stigma. Stigma capitate, symmetrical, cavernous within because of the large deep-seated oil-glands (fig. 1). Fruits small, 18–35 mm. long, 18–25 mm. in diameter, oval or globose; peel rather thick, fleshy and aromatic, sweet-flavored, containing numerous large immersed oil-glands. Segments 3–6, rarely 7 (figs. 2–5); pulp vesicles small, fusiform or subglobose, stalked, containing an acid juice. Seeds ovate in outline, smooth; embryo pistache green. Germination with hypogeous cotyledons; first foliage leaves broadly ovate, subsessile, opposite as in Citrus.

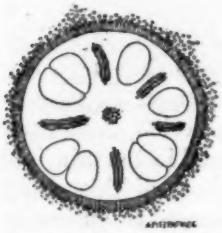

Fig. 1. *F. japonica*. Cross-section of stigma, showing large oil glands between stylar canals, three of them double, two single. Scale 25.

Type species, **Fortunella margarita** (*Citrus margarita* Lour.), cultivated at Canton, China.

The genus Fortunella resembles Citrus in the general appearance of the stems, twigs, spines, leaves, flowers, and fruits and in having the polyadelphous stamens normally four times as numerous as the petals. It differs from Citrus (1) in having an isomerous or hypomerous ovary, normally 3–5-celled (rarely 6 or 7-), not polymerous (8–15- or more celled), (2) in having two collateral ovules in each cell (not 4–12), (3) in having a cavernous stigma containing a few large, deeply immersed, lysigenous oil glands (not asymmetrical and solid or nearly so), (4) in having the under surface of the leaves pale green, nearly veinless and with very numerous, small, deep green glandular dots, (5) in having a sweet and edible, more or less pulpy skin, and (6) in having small more or less angular flower buds.

Fortunella approaches Atalantia and differs strikingly from Citrus in having only two collateral ovules near the top of each cell, whereas Citrus has 4–12 ovules to a cell. Fortunella differs from Atalantia in having twice as many stamens (four times as many, instead of twice as many, as the petals), and in its general agreement with Citrus in twig, leaf, spine, flower, and fruit characters.

The capitate stigmas of all the species of Fortunella contain large oil glands imbedded in their substance, which renders them cavernous.[5] (See fig. 1.) The stigma of Citrus contains a few scattering oil glands, sometimes one in every space between the radially arranged and expanded stylar canals; but these glands are very near the surface and relatively so small that the stigma lacks entirely the cavernous structure characteristic of Fortunella.[6] The leaves show very many more oil glands on the underside than in any species of Citrus, often ten times as many.

In superficial fruit characters Fortunella agrees with the Australian desert kumquat (*Eremocitrus glauca*) in many respects. The seeds are very different, however, and the stem, twig, leaf, and flower characters are so strikingly different that it is not possible to regard these genera as closely related.

There are four species of Fortunella known at present. The two commonly cultivated species, the round and oval kumquats of China and Japan, together with the Meiwa kumquat, comprise the subgenus **Eufortunella,** distinguished by several important characters from the Hongkong wild kumquat for which a new subgenus, **Protocitrus,** is described farther on in this paper.

THE SUBGENUS EUFORTUNELLA

The species of Eufortunella may be distinguished by means of the following key:

Fruits globose, 20–25 mm. in diameter, 4 or 5-celled; seeds small, bluntly rounded at tip; leaves pale and veinless below, blunt-pointed.....2. *F. japonica.*

[5] This was noticed as early as 1784 by Thunberg (Fl. Jap. 293), who said, "Stigma . . . . intus multiloculari," in describing the round kumquat; since then no one seems to have observed this fact.

[6] Penzig, O. A. J. Studi Botanici sugli Agrumi e sulle Piante Affini, pp. 53–75; atlas, *pl. 6.* (Ann. di Agr. no. 116). 1887.

Fruits oval or oblong, 5–7-celled; seeds more or less pointed at tip; leaves narrowed toward the tip.

Fruits oblong, 25–33 mm. long, 20–25 mm. in diameter, usually 5 or 6-celled; petiole narrowly margined, not winged; pulp vesicles fusiform.....1. *F. margarita.*

Fruits oval or subglobose, 28–35 mm. long, 22–30 mm. in diameter, 6 or 7-celled; leaves very thick; petiole plainly but narrowly winged at tip; vesicles subglobose or oval.....3. *F. crassifolia.*

THE OVAL KUMQUAT

The oval kumquat has been referred by most botanists to *Citrus japonica* Thunb., which is based on the round kumquat. These two kumquats are certainly very closely related, but as they show constant differences of some taxonomic importance in nearly all parts of the plant, it seems best for the present to consider them as constituting two distinct species.

1. **Fortunella margarita** (Lour.) Swingle.

Citrus margarita Lour. Fl. Cochin. **2:** 467. 1790.

Citrus aurantium olivaeformis Risso, ex Lo'sel.-Desl. & Michel, Nouv. Duham. **7:** 95. 1816.

Citrus aurantium var. *japonica* Hook. f. Curt. Bot. Mag. III. **30:** *pl. 6128.* 1874.

Citrus japonica var. fructu elliptico Sieb. & Zucc. Fl. Jap. **1:** 35. *pl. 15, fig. 3.* 1835.

Citrus Aurantium subspec. *japonica* var. *globifera* subvar. *margarita* Engl. in Engl. & Prantl, Pflanzenfam. **3[4]:** 199. 1896.

TYPE LOCALITY: Canton, China (in culture).

The type specimen of *Citrus margarita* seems to have been lost, but Loureiro's description is very good and can apply only to an oval kumquat very similar to the one commonly cultivated today in all the warmer parts of the world.

A lectotype (*Swingle;* C. P. B. No. 7955; February 18, 1915), consisting of a branch of an oval kumquat tree growing in a greenhouse of the Department of Agriculture at Washington, has been deposited in the National Herbarium at Washington.

The oval kumquat differs from the round chiefly in the following respects: (1) The leaves are larger, more acute at the base, less pallid and more veiny below; (2) the ovary has usually 4 or 5 cells, very rarely 3 or 6; (3) the fruit is oval, not globose; (4) the style is persistent, not caducous; (5) the seeds are larger and especially longer, with a rougher testa. (Fig. 2.) It differs also in being distinctly more

vigorous and attaining a greater height (10–12 ft.); in the somewhat brighter orange color of its fruits; and especially in the harsher, more biting flavor of the peel, which evidently contains an etherial oil more nearly resembling that of the common orange than does that of the round kumquat.

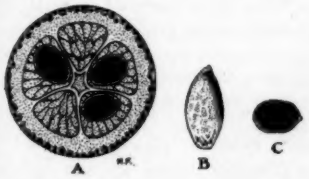

Fig. 2. *F. margarita*. *A*, cross-section of 5-celled fruit; *B*, seed; *C*, seed in cross-section. All natural size.

Fig. 3. *F. japonica*. *A*, cross-section of 5-celled fruit; *B*, seed; *C*, seed in cross-section, showing polyembryony. All natural size.

THE ROUND KUMQUAT

2. **Fortunella japonica** (Thunb.) Swingle.

金柑 *Chin Kan*, vulgo Fime Tatsbanna. Malus Limonia, fructu pumilo aureo, medullâ dulci. Kaempf. Amoen. Exot., fasc. 5, 801. 1712.

Limonellus madurensis Rumph. Hort. Amboin. **2**: 110. *pl. 31*. 1741.

Citrus japonica Thunb. Nov. Act. Upsal. **3**: 199. 1780.[7]—Fl. Jap. 292. 1784.—Icon. Pl. Jap. **2**: [*pl. 5*]. 1800.

Citrus madurensis Lour. Fl. Cochin. **2**: 467. 1790.

Citrus inermis Roxb. Fl. Ind. **3**: 393. 1832.

Citrus microcarpa Bunge, Mém. Acad. Imp. Sci. St. Petersb. **2**: 84. 1833.

Citrus japonica var. fructu globoso Sieb. & Zucc. Fl. Jap. **1**: 35. *pl. 15, fig. 2*. 1835.

Citrus Aurantium subspec. *japonica* var. *globifera* Engl. in Engl. & Prantl, Pflanzenfam. **3**[4]: 199. 1896.

TYPE LOCALITY: Japan (in culture).—Native in China.

[7] The original publication of this species by citation is on p. 199 as follows: "Kin Kan, vulgo Fime Tats
'banna, p. 801. *Citrus Iaponica.*"
Under the heading Characters of New Species it is given as follows, on p. 208: 'Citrus japonica: petiolis alatis, foliis acutis; caule fruticoso."
The species is published by the citation on page 199, inasmuch as Kaempfer identifies the plant not only by giving the Chinese characters never applied to any other plant but also the Japanese common name and a short latin phrase sufficient to distinguish it from any other Citrus.

The differences between the round and oval kumquats have already been enumerated under the latter species. (See figs. 2 and 3.)

No type specimen of this species exists, but the specimen figured by Thunberg probably is to be found in the Upsala Museum and may after critical examination prove suitable to be considered a lectotype.

The plants grown in Japan, United States, Europe and North Africa are almost all grafted and consequently show great uniformity.

THE MEIWA, A NEW KUMQUAT, POSSIBLY OF CHINESE ORIGIN

About 1896 or 1897 a new kumquat appeared in Japan, apparently imported from China. It seems to have been listed at first as the Chinese large-fruited kumquat, but soon came to be known as the spotted Meiwa kumquat,[8] and soon simply as the Meiwa kumquat.[9]

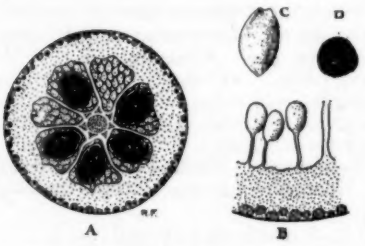

Fig. 4. *F. crassifolia*. *A*, cross-section of 7-celled fruit; *B*, oval pulp vesicles, growing into cell from inner wall of ovary; *C*, seed; *D*, seed in cross-section. *A*, *C*, and *D*, natural size; *B*, scale 1½.

This variety is very prolific, even small shrubs bearing an abundance of fruit. The leaves are decidedly different from those of any other kumquat, being much thicker and folded on the midrib so as to be V-shaped in cross-section. The fruits are slightly oval, often nearly globose, decidedly larger than those of the round kumquat, and distinctly broader at the equator than those of the oval kumquat. They show in cross-section 5, 6 or 7 segments, with one or two seeds in each segment. (Fig. 4.) Upon close study these differences seem to necessitate the recognition of the Meiwa kumquat as a new species.[10]

[8] Hidaka, Kwaji Yen, in Nippon yen gei zatto shi (Bull. de la Soc. d'Horticolture du Japon) **23**: 44. May, 1911.

[9] Some nurserymen give also a variety Nei wa; others consider these synonymous, preferring Meiwa.

[10] **Fortunella crassifolia** Swingle, sp. nov. A speciebus ceteris *Fortunellae* differt foliis crassioribus, canaliculatis, in sectione **V**-formibus, cellulis paliformibus in 4–6 stratis dispositis, fructibus majoribus ovoideis, 5–6–7–locularibus, vesiculis ovoideis vel ellipsoideis nec fusiformibus.—Habitat in China?, cult. in Japonia et America.

3. **Fortunella crassifolia** Swingle, sp. nov.

A dwarf tree or a shrub, often thornless, sometimes with short stout spines 3–10 mm. long; twigs slender, 2.5–5 mm. in diameter, angled when young, dark green, often tufted at the ends of the branches. Leaves lanceolate or ovate-lanceolate, 4–9 (usually 6–8) cm. long, 1.5–4 (usually 2–3.5) cm. broad, tapering toward both ends, often rather sharply, rarely rounded and emarginate at the tip, the base cuneate (especially when not articulated with the tip of the petiole), sometimes more or less broadly rounded; margin entire below the middle and sometimes nearly to the tip, but usually obscurely crenate in the upper third or half; leaves very thick and rigid, folded along the midrib so as to be more or less U- or V-shaped in cross section, on the upper surface glossy dark green, or more or less yellowish green, with veins scarcely visible, paler on the under surface, dotted with very numerous dark green oil-glands and obscurely veined; petioles 7–10 mm. long, at base subcylindric, 1–2 mm. in diameter, the tip narrowly winged, 2.5–4 mm. wide, often not articulated with the blade, the winged petiole then merging imperceptibly into the cuneate base of the leaf. Flowers occurring singly or in pairs in the axil of the leaf, buds at first 5-lobed at the tip, later more or less 5-angled in cross section. Fruits broadly oval or ovate in outline, 25–35 by 25–28 mm., usually 5–7-celled with one or two seeds in a cell, some of the cells usually without perfect seeds. Seeds oval, 9–12 by 5–7 by 4–6 mm., blunt-pointed at both ends; testa larger than the embryo and more or less wrinkled at the projecting ends; embryos often several, green.

Type in the U. S. National Herbarium, no. 694952, consisting of a fruiting branch taken from a cultivated plant in the greenhouse of the U. S. Department of Agriculture, Washington, D. C., *Swingle* (C. P. B. No. 7496–C), February 17, 1915. Merotype,—flowering branch, *M. Kellerman*, February 23, 1915. Additional specimens from nurseries at Port Arthur and Alvin, Texas, are in the U. S. National Herbarium.

This species, although differing in many important characters from the two commonly cultivated species of kumquats, may nevertheless on more thorough study prove to be of hybrid origin or else a mutation. The precocious and abundant fruiting and the presence of many good seeds in the fruits would seem, however, to indicate that it can scarcely be a hybrid between two very distinct species. Besides, it is not easy to see what species could have been hybridized to produce such a form.

In many ways the Meiwa kumquat shows a marked intensification of the characteristics of the true kumquats. Such intensification may result from hybridization or from mutation but may also be the result of long continued, slow, evolutionary change. In any case, the present form doubtless merits a distinctive name, such as is given commonly to

hybrids between well marked species and to stable forms of mutative origin.

The very thick and rigid leaves of the Meiwa kumquat show 4 or 5 or even more layers of palisade tissue on the upper side of the leaf. The other two species show only 2 or 3 layers of palisade.

THE SUBGENUS PROTOCITRUS

The Hongkong kumquat, *Fortunella Hindsii*, differs from the round kumquat (*F. japonica*), the oval kumquat (*F. margarita*), and the Meiwa kumquat (*F. crassifolia*) in a number of morphological characters, some of them of decided taxonomic significance in this group. It may be regarded as constituting a new subgenus:

PROTOCITRUS Swingle.[11] Differs from Eufortunella (1) in having the ovary hypomerous (3 or 4-celled, not 5-celled); (2) in the ovary wall of the mature fruits having on the inside between the stalks of the pulp vesicles a number of minute, wartlike, pale yellow, cellular masses (fig. 5); (3) in having the dissepiments of the fruit dry, and the peel thin and not very fleshy; (4) in having shorter, broader, more brachytic flowers; (5) in having leaves with the veins more prominent on both faces, and less pallid below.

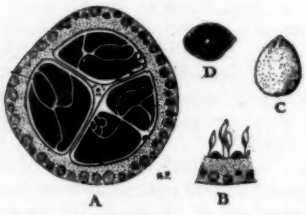

Fig. 5. *F. Hindsii*. *A*, cross-section of 3-celled fruit, one cell having 2 seeds, another showing a few pulp vesicles; *B*, fusiform vesicles and verruciform tissue growing into cell from inner wall of ovary; *C*, seed; *D*, seed in cross-section, showing polyembryony. *A*, *B*, scale 2; *C*, *D*, natural size.

The two most important characters distinguishing the subgenus Protocitrus from Eufortunella are the few-celled ovary and the dimorphic *emergencen* from the ovary wall of the fruit, viz.: ordinary pulp vesicles and verruciform tufts of loosely aggregated more or less colored cells. (Fig. 5, B.)

[11] **Protocitrus** Swingle, subgen. nov. A *Eufortunella* differt ovariis hypomeribus (3- vel 4- nec 5-locularibus) parietibus dorsalibus locularum fructus maturi verrucosis, verrucis e cellulis luteolis compositis, dissepimentis membranaceis non succosis, exocarpio tenuiori minus succoso, floribus brevioribus latioribus, foliis subtus viridioribus, venis conspicuioribus.

The Hongkong kumquat, which, as already indicated, is the sole species of the subgenus Protocitrus, may be described as follows:

Fortunella Hindsii (Champ.) Swingle.

Sclerostylis Hindsii Champ. Hook. Journ. Bot. III. **3**: 327. 1851. *Atalantia Hindsii* Oliver ex Benth. Fl. Hongkong. 51. 1861.—Journ. Linn. Soc. **5**, Suppl. 2: 26. 1861.

A spiny shrub or small tree; twigs slender, angled when young; leaves oval-elliptical, tapering sharply at both ends, dark green above and faintly venose, paler and venose below; petioles winged, often merging into the lamina of the leaf without a separative joint. Flowers short, broad, not opening very widely; pistil very short; style shorter than the ovary; stigma large, cavernous; ovary 3 or 4-celled; ovules 2 in a cell. Fruits small, 1.5–2 cm. in diameter, subglobose, bright orange red when ripe, the color of a tangerine orange; pulp vesicles very few, small, fusiform; seeds thick, oval or ovate in outline, plump, 9–11 by 7–8 by 5–6 mm., pistache green in section.

TYPE: Hongkong, *R. B. Hinds*, without number, 1841; a much branched twig with spines, leaves, fruit pedicels, and one young fruit.[12] (Mounted on the same sheet are two twigs collected by Wright.) Herb. Kew.

The Hongkong wild kumquat grows commonly on the dry hills about Hongkong and on the mainland of China opposite.

Much other material from Hongkong and some from Kaulung, on the mainland opposite Hongkong, has been examined by the writer in the collections at Kew, British Museum, Muséum d'Histoire Naturelle, Gray Herbarium, and U. S. National Herbarium. Living plants grown in the greenhouses of the Department of Agriculture from seeds from Hongkong have permitted a comparison of this plant at all stages of growth with the other species of Fortunella.

UTILIZATION OF THE KUMQUATS IN BREEDING NEW TYPES OF CITROUS FRUITS

In connection with the attempt to breed hardy citrous fruits the attention of the writer was directed some years ago to the kumquat oranges, which are particularly remarkable for their very small size

[12] A label in Bentham's (?) writing, reading "*Atalantia monophylla* DC. Hong Kong, Hinds, 1841," is pasted across the base of the twig, which shows it to be without doubt the specimen cited by Bentham (Lond. Journ. Bot. **1**: 480–481. 1842). Some of the petioles of this twig exhibit the curious imperfections in the articulation with the blade characteristic of this species; so it is possible to identify this specimen beyond question.

and for having a relatively thick, sweet, and edible peel. These diminutive fruits, borne on correspondingly dwarfed trees or shrubs, have been found to possess in very high degree winter dormancy, which is so essential to hardiness in citrous fruits grown in the variable climate of Florida and the Gulf States. Recently the kumquat oranges have also been found to be remarkably resistant to citrus canker, the most dreaded of all the diseases affecting citrous trees in the United States. Indeed, many investigators have not succeeded in finding any canker infection on kumquat oranges, and believe them to be immune. Furthermore, hybrids between the two commonly cultivated species of kumquat, the oval and the round-fruited, on the one hand, and the common lime on the other, have proven not only to be very resistant to cold, but to possess a considerable degree of resistance to citrous canker.

ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. Each of the scientific bureaus in Washington has a representative authorized to forward such material to this journal and abstracts of official publications should be transmitted through the representative of the bureau in which they originate. The abstracts should conform in length and general style to those appearing in this issue.

METEOROLOGY.—*Frost protection.* W. J. HUMPHREYS. Monthly Weather Review, **42:** 562–569. 1914.

This paper deals entirely with the scientific or theoretical side of orchard heating and other methods of frost protection. It is explained that when frost is most likely to occur, that is, during still clear nights, temperature inyersions (increase of temperature with increase of elevation) commonly obtain almost everywhere except on hills and mountains at some elevation above the intervening valleys. This temperature inversion keeps any air that may be artificially warmed near the surface where it may be effective in preventing frost. But for this inversion that acts like a ceiling in restricting vertical convection, the warmed air would rise quite above the tree tops and thus do but little good.

Computations, based on the rate of loss of heat by radiation during clear nights, show that the amount of petroleum necessary to protect a large orchard from frost is, roughly, one liter per tree per hour. Air drainage (so important to consider in locating an orchard), ground covering, screens, sprays, smudges, dry heating and irrigation are all considered. W. J. H.

CHEMISTRY.—*The reaction of cows' milk modified for infant feeding.* WILLIAM MANSFIELD CLARK. Journal of Medical Research, **31:** 431. 1915.

By the use of the hydrogen electrode the hydrogen ion concentrations of human and cows' milk have been compared with those of various formulae of cows' milk modified for infant feeding. The addition of alkalies to modified milk for the purpose of neutralizing the so-called "high acidity of cows' milk" is shown to be a practice not only

based upon wrong principles, but a practice which in some instances produces a reaction far too low for even favorable pancreatic digestion. The addition of alkalies to modified milk for the purpose of preventing firm clots of casein in the stomach is shown to be a procedure which may not only be unnecessary to accomplish this purpose, but one which may involve inhibition of gastric proteolysis and lipolysis. Finally, the addition of alkalies to modified milk is criticized because of its tendency to displace from the intestine a normal fermentative bacterial flora and to favor bacterial proteolysis or "putrefaction."

W. M. C.

PHYSICAL CHEMISTRY.—*The ternary system: diopside-forsterite-silica.* N. L. BOWEN. Am. Jour. Sci. (4), **38:** 207–264. 1914.

The results obtained in the investigation of the three binary systems involved are first presented. The system diopside-silica shows the simple eutectic relation, as does also the system diopside-forsterite. The system forsterite-silica shows one intermediate compound, $MgSiO_3$ (clino-enstatite), unstable at its melting-point.

In the ternary system it is found that clino-enstatite and diopside form a complete series of solid solutions (monoclinic pyroxenes) and therefore have a common field. As a further consequence of this unbroken series of solid solutions there is no ternary eutectic, the lowest point of formation of liquid in the system being the binary eutectic diopside-silica.

A brief theoretical discussion of solid solution in ternary systems is given. The course of crystallization in typical mixtures of the present ternary system is described, and the value of certain lines termed three-phase-boundaries is pointed out, especially their usefulness in determining the composition of mix-crystals separating at any temperature. In considering crystallization it is shown that crystallization may proceed according to two different methods: first, that in which the liquid is, at any temperature, in equilibrium with all the crystals and all parts of the crystals occurring in it, and second, that in which the liquid is in equilibrium at any temperature only with the crystals separating at that temperature. In a general way, crystallization of the second type is favored by quick cooling.

The importance of distinguishing between the two types of crystallization is great in the present system. It is shown that the difference between the conclusions arrived at in the present work and those arrived at in an earlier investigation of the pyroxene series carried out at this Laboratory is due largely to the fact that in the earlier work crys-

tallization of the second type occurred in many of the mixtures, whereas, if equilibrium is to be studied, crystallization of the first type must be obtained.

In the optical part of the paper the optical properties of the various crystalline phases are given. The properties of the series of monoclinic pyroxenes extending from diopside to enstatite vary continuously with composition. The artificial pyroxenes are compared with the enstatite-augites of Wahl.

In considering the bearing of the results on petrologic problems attention is called to the resorption of the olivine forsterite in the artificial mixtures and its probable relation to resorption of olivines in natural rocks. The consequences of the possible settling of crystals in a fluid magma (crystallization-differentiation) are discussed in the light of the facts known concerning the artificial mixtures. N. L. B.

MINERALOGY.—*Hewettite, metahewettite, and pascoite; hydrous calcium vanadates.* W. F. HILLEBRAND, H. E. MERWIN, and FRED. E. WRIGHT. Proc. Am. Phil. Soc., **53**: 31–54. 1914.

Two apparently different calcium vanadates are described, which resemble each other very closely and have the same composition ($CaO \cdot 3V_2O_5 \cdot 9H_2O$) when holding their maximum water-content at room temperatures. One of them, hewettite, occurs at Minasragra, Peru, and has been noticed on a single specimen from Paradox Valley, Colorado. The other, metahewettite, occurs at numerous localities in western Colorado and eastern Utah. Both minerals are sparingly soluble in water.

A third calcium vanadate, pascoite ($2CaO \cdot 3V_2O_5 \cdot 11?H_2O$,) is also described. This occurs with hewettite at Minasragra. It is very soluble in water.

The first and second minerals are regarded as dehydrated acid hexavanadates ($CaH_2V_6O_{17} \cdot 8H_2O$), the third as a normal hexavanadate ($Ca_2V_6O_{17} \cdot 11?H_2O$).

The reasons for specific separation of hewettite and metahewettite are set forth in detail. The two minerals are so sensitive to changes in atmospheric humidity that their water-content varies within wide limits at different times of the year. The removal of all or nearly all the water does not result in breaking down of the crystal structure, and until this has occurred the water is wholly or in great part taken up again when opportunity is offered.

The importance is emphasized of bringing all minerals that behave in this way to a definite maximum water-content before analyzing them

and of following carefully the course of dehydration under prescribed conditions. Detailed directions are given for such tests and for avoiding several sources of error.

Attention is also called to two fairly constant associates of metahewettite. One of these (also a constituent of carnotite ores) is a gray hydrous silicate of aluminum, trivalent vanadium, and potassium. The other is elemental selenium, the existence of which as a mineral species seems now for the first time established. W. F. H.

PETROLOGY.—*An occurrence of pyroxenite and hornblendite in Bahia, Brazil.* HENRY S. WASHINGTON. Am. Jour. Sci. (4), **38:** 79–90. 1914.

The igneous mass occurs near Maracas, in the State of Bahia, intruded into gneisses. The central part is a hornblendite and the outer a pyroxenite, both being exceptionally fresh. Complete analyses of the two are given and their relations to other occurrences are discussed. Both rocks are notable for the large amount of manganese which they contain, which is correlated with the abundance of manganese ores in this part of the State of Bahia. There is also a notable amount of copper. H. S. W.

PETROLOGY.—*The mode of formation of certain gneisses in the Highlands of New Jersey.* CLARENCE N. FENNER. J. Geology, **22:** 594–612; 694–702. 1914.

The paper deals with certain geological phenomena which have been observed in an area of ancient crystalline rocks in northern New Jersey, and discusses the manner in which the structures in question have originated. The manner of action of the processes is considered, not only from the geological side, but also from physical and chemical standpoints. A description is first given of the structural relations of the gneisses as observed in the field, and evidence is presented leading to the belief that at this locality the foliation of the gneisses can not well be attributed to the squeezing-out of a partly differentiated magma or to the shearing and recrystallization of a solidified rock, but that its origin must be looked for in a process involving the injection of a thinly fluid granitic magma between the layers of an original rock of a laminated character. Evidence is found which indicates that the process of injection was carried out in a most quiet and gradual manner, and possessed many of the characteristics of a substitution of the original material by the magmatic solution rather than the features of a violent intrusion. The observed relations are very similar to those which certain French geologists have described under the name of *lit-par-lit* in-

jection, and the mode of operation is believed to have been essentially the same.

Certain features which were observed in the gneisses imply properties of the magma which at first sight do not appear mutually consistent. Thus the degree of viscosity implied by the presence of thinly tabular sheets of inclusions within the granite, standing nearly upright and unsupported except by the magma on either side, does not harmonize with the facility with which magmatic material has been transfused into the original rock. In trying to reconcile these features inquiry has been directed toward a consideration of certain of the physical and chemical properties of magmatic solutions. The question of the critical temperatures of volatile substances is discussed in its bearing upon their condition within the magma. Further, the question of the possibility of a viscous magma penetrating the pores of the wall-rock is considered and the problem of a possible differentiation of a magma when injected between the layers of a rock in a multitude of adjacent streams is taken up. Certain inferences are drawn regarding the operation of such processes and the conclusion is reached that under such conditions of injection as prevailed at this locality, the advance of the main body of magma would be preceded by that of a more dilute portion, which would be able to impregnate the wall-rock with facility and initiate processes of transformation and solution which the more concentrated body following would carry farther toward completion. C. N. F.

GEOLOGY.—*The Shinumo Quadrangle, Grand Canyon District, Arizona.* L. F. Noble. U. S. Geological Survey Bulletin No. 549. Pp. 100. 1914.

The Shinumo quadrangle lies in the western part of Kaibab division of Grand Canyon, Arizona. Geological formations that outcrop are exposed in cross-section in walls of the mile deep canyon. They are, in age: Archean, Algonkian, Cambrian, Devonian, and Carboniferous. The Archean and Algonkian, and the Algonkian and Cambrian are separated by profound angular unconformities of erosion. The Cambrian and Carboniferous are separated by an unconformity of erosion without unconformity of dip. Devonian strata are present only here and there; they were deposited in shallow depressions in the eroded surface between the Cambrian and Carboniferous.

The Archean includes the Vishnu schist, made up of gneisses, schists, quartzites, and plutonic intrusive rocks. In the region about the mouth of Shinumo Creek it is a metamorphic complex of quartz, mica, and hornblende schists which are invaded by a mass of quartz diorite

and injected by veins of pegmatite and aplite. Farther down the river, gneisses are the prevailing rocks. The schists are believed to be of sedimentary origin, the gneisses, igneous.

About 5000 feet of strata of the Unkar group, Algonkian, Grand Canyon series, are present. They lie in a wedge-shaped mass that is inset in the Vishnu schist by block-faulting along the line of the West Kaibab fault, and are intruded by a sill of diabase 1000 feet thick. Five formations are differentiated: Hotauta conglomerate, overlain by Bass limestone, Hakatai shale, Shinumo quartzite, and Dox sand-stone.

The Cambrian is divided into three formations: Tapeats sandstone, overlain by Bright Angel shale and Muav limestone. The Carboniferous comprises Redwall limestone, Supai formation, Coconino sandstone, and Kaibab limestone. These beds have a gentle southwesterly dip of 100 to 200 feet to the mile. Plateau surfaces on both sides of the canyon are developed on same hard formation, the Kaibab limestone. Course of canyon is at right angles to dip of strata. Therefore the land north of canyon slopes toward the brink, and the land south slopes away; therefore the attitude of the canyon is like that of a trench dug along a hillside. Drainage of plateaus on both sides of the canyon runs southwesterly with the initial slope of the land; on south side of canyon the heads of many plateau valleys are truncated by the southern wall of the canyon.

The factors chiefly responsible in determining topographic form in the canyon country are: the horizontal attitude of the beds; horizontal continuity and vertical variation (alternation of hard and soft); faults traversing them; great height of land above the sea; and aridity of the climate. There is, however, another factor whose importance has not been realized: this is the influence of minor joints and fractures not associated with notable displacement. The courses of most of the smaller side-gorges have been guided by these fractures and most of the buttes and temples have been blocked out by them.

The Esplanade, a wide terrace which runs through the Kanab division of the canyon, is not, as has been thought, a local base-level due to a pause in the uplift of the region, but is a structural bench developed, like the Tonto Platform of the Kaibab division, on one of the hard sets of beds in the Paleozoic.

Examples of pre-Cambrian faults of which the West Kaibab fault is the most notable, additional to those already known along which movement has recurred in post-Paleozoic time, are described and the wide prevalance of this phenomenon in the Grand Canyon region is shown. L. F. N.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

THE WASHINGTON ACADEMY OF SCIENCES

The 94th meeting of the Washington Academy of Sciences was held in the lecture room of the Cosmos Club, the evening of December 3, 1914, with President DAVID WHITE in the chair, and about 40 persons present.

Mr. HENRY S. GRAVES, Chief of the U. S. Forest Service, gave an interesting and instructive talk on *The place of forestry among natural sciences.* (This JOURNAL, **5**: 41. 1915.)

The 95th meeting of the Washington Academy of Sciences, a joint meeting with the Botanical Society of Washington, was held in the lecture room of the Cosmos Club, the evening of January 5, 1915. The hall was crowded, and many were turned away.

Prof. J. C. BOSE of India gave an illustrated lecture on *The response of plants.* The lecturer dealt chiefly with his own extensive investigations which have shown a remarkable parallelism between the response of animals and the response of plants to a wide variety of stimuli. The apparatus used and methods of work were explained, the conclusions enumerated, and in one or two cases an actual plant response was shown to the audience.

The 96th meeting of the Washington Academy of Sciences, the 16th annual meeting, was held in the lecture room of the Cosmos Club, the evening of January 14, 1915, with President DAVID WHITE in the chair and about 100 persons present. The following were elected officers for the ensuing year: *President*, R. S. WOODWARD; *Corresponding Secretary*, GEORGE K. BURGESS; *Recording Secretary*, W. J. HUMPHREYS; *Treasurer*, E. W. PARKER; *Vice-Presidents*, representing the: Anthropological Society, F. W. HODGE; Archaeological Society, MITCHELL CARROLL; Biological Society, PAUL BARTSCH; Botanical Society, W. E. SAFFORD; Chemical Society, CARL L. ALSBERG; Electrical Engineers Society, E. B. ROSA; Engineers Society, WILLIAM BOWIE; Entomological Society, W. D. HUNTER; Foresters Society, G. B. SUDWORTH; Geographical Society, O. H. TITTMANN; Geological Society, ARTHUR KEITH; Historical Society, J. D. MORGAN; Medical Society, FRANK LEECH; Philosophical Society, W. S. EICHELBERGER; *Non-Resident Vice-Presidents*, C. C. NUTTING and E. C. FRANKLIN; *Managers, Class of 1918*, L. STEJNEGER and W. H. HOLMES.

After the list of new officers was read the newly elected president, Mr. R. S. WOODWARD took the chair, and the retiring president, Mr. DAVID WHITE gave his address on *Some relations in origin between coal and petroleum*. No review of this excellent paper need be given here as it will soon appear in the JOURNAL.

After this address the Recording Secretary read the minutes of the previous annual meeting and of the various other meetings, all of which was approved. The report of the Corresponding Secretary showed the total membership of the Academy to be 414, a net gain of 46 for the year. It also reminded the Academy that while it had gained largely in numbers it had also suffered severely in the loss by death during the past year, of the following members: Resident, HENRY GANNETT, THEODORE GILL, BERNARD R. GREEN, A. F. A. KING, and F. W. TRUE; non-resident, W. L. DUDLEY, FREDERICK FORCHHEIMER, JOHN MUIR, D. E. SALMON, and NEWTON H. WINCHELL.

The Treasurer's report showed: Total receipts $4,937.69, disbursements $3,340.38, cash on hand $1,597.31, investments $12,590. The report of the Auditing Committee confirming that of the Treasurer, was also received.

The Board of Editors gave an interesting report in which they showed by a number of diagrams the healthy and parallel growth of the Academy and its JOURNAL.

The 97th meeting of the Washington Academy of Sciences, a joint meeting with the Biological Society of Washington, was held the evening of January 19, 1915, in the Auditorium of the National Museum. Vice-President PAUL BARTSCH, President of the Biological Society was in the chair and an audience of about 100 present.

Dr. JOHAN HJORT, director of the fisheries of Norway, gave a talk on *Migrations and fluctuations of the marine animals of western Europe*. The distances and prevailing directions of migration of fish were determined by setting free large numbers that had been properly tagged and noting the times and places of their subsequent capture. This also gave an idea of the ratio, not far from 1 to 10, of the catch of any given year to the total number of fish available.

It was also explained that fish scales have rings indicative of annual growth from which one can safely infer not only the age of any given specimen but also, by the distance between the rings, the amount of growth during any particular year of its life. By these means it was learned, among other things, that fish, whatever their individual ages, grow much faster during certain years than during others. Also that there are great inequalities in the relative numbers of fish of different ages, in some cases the number of one age exceeding the number a year or even two years younger.

In addition to its scientific interest this investigation has already greatly increased and rendered more profitable the enormous fishing industry of Norway and, presumably, that also of adjacent countries.

W. J. HUMPHREYS, *Recording Secretary*.

THE GEOLOGICAL SOCIETY OF WASHINGTON

The 290th meeting was held in the lecture room of the Cosmos Club, on January 27, 1915.

INFORMAL COMMUNICATIONS

R. S. BASSLER: *Unconformities in limestone.* At a previous meeting remarks had been made to the effect that the Silurian limestones of a certain area passed without break into the Devonian. This suggested to the speaker the idea of citing examples where this was apparently so, but where in reality an unconformity of great extent was present. A fragment of limestone, only a few inches thick, from Louisville, Kentucky, crowded with Middle Devonian fossils on one side and Middle Silurian fossils on the other, was exhibited to show that such unconformities exist in what is now the same layer. Hand specimens of Ordovician limestone preserving the unconformity between the lower Chazy and Black River formations and taken from the same bed were also exhibited. In fresh fractures the unconformity can hardly be detected, but upon weathered surfaces it is shown as a distinct wavy line.

Discussion: G. F. LOUGHLIN remarked that Bassler's examples were duplicated in certain occurrences in the Tintic District. T. WAYLAND VAUGHAN spoke of the contact of Cretaceous and Eocene limestones along the Frio River in Texas. The two formations were so similar that it was only by fossils that the hiatus could be detected, but after the necessity for it had been discovered a thin band of pebbles was found at the contact.

REGULAR PROGRAM

E. S. BASTIN and J. M. HILL: *Ore deposits of Gilpin County, Colorado.* (Published in full on pp. 160–164 of this issue of the JOURNAL.)

Discussion: F. L. RANSOME inquired regarding the genetic connection between the different classes of ore-bodies, and if there were any indication of the galena giving out with depth. BASTIN replied that the genetic connection was not entirely clear in all cases, but the uranium ores are probably a local phase of the gold-silver ores. The tungsten ores seem to be so localized as to indicate that an unusual phase of magmatic differentiation had been accompanied by an unusual phase of ore-deposition. With regard to the second query—the deposition of galena-sphalerite ores followed a second period of fracturing and occupied the spaces thus opened, and also partly replaced primary ores. The natural consequence is that at ends of veins and bottoms of veins the earlier minerals predominate. It is not certain, however, that some galena-sphalerite veins may not persist. F. L. HESS said that his experience in a portion of the district indicated that tungsten ores, where found, did not completely take the place of other ores. BASTIN agreed. J. B. UMPLEBY inquired regarding the sequence in time and space of the pyritic veins and the galena-sphalerite veins. BASTIN replied that this brought up an interesting but complex problem. He referred to J.

E. Spurr's conclusion that pyritic veins occurred nearer the igneous source and the galena-sphalerite type farther away. The ores of the Erzgebirge show somewhat similar relations. In the Colorado occurrence which he had described there were indications of a halt between the periods of deposition of the two types. It was quite a problem to account for this pulsation of deposition. G. F. LOUGHLIN spoke of analogous occurrences in the Tintic District.

STEPHEN R. CAPPS, JR. *An estimate of the age of the last great glaciation in Alaska.* (This JOURNAL, **5**: 108–115. 1915.)

Discussion: DAVID WHITE spoke of similar root-development observed in connection with coal beds. He wondered if the top of the till showed evidence of a milder climate (such as oxidation), also if there had been a hiatus before the deposition of peat began. He also raised the question of possible shrinkage in the bottom layers of peat. If the peat had been constantly frozen at all periods probably not much shrinkage had taken place. CAPPS replied that the actual contact of peat and till was not well exposed at any place, but in the till itself there was no evidence of oxidation. As to the frozen condition—probably decay had been checked by this. A. H. BROOKS expressed the opinion that the accumulation of frozen material over the till in this place is comparable to that in other parts of the Yukon Basin and that the frozen state had persisted since the glacial period. D. W. WHITE spoke on counting the growth-rings of the trees. He thought that in that climate this should give remarkable precision, as there was little chance of a second ring forming in a year. W. C. ALDEN thought that there was little likelihood of evidences of oxidation showing on top of the till in that region, considering the small amount shown at top of Wisconsin till in milder latitudes. T. WAYLAND VAUGHAN spoke of an interesting calculation he had made in connection with the theory that the submergence of the platforms on which coral reefs have grown has been due to the melting of the glacial ice-cap. He had calculated the time necessary for the Great Barrier Reef to grow to its present thickness, and had made it 11,000 years, showing close agreement with CAPP'S calculations.

E. DE K. LEFFINGWELL: *Ground ice wedges. The dominant form of ground ice on the north shore of Alaska.* The permanently frozen ground contracts in the cold Arctic winter and cracks are formed which divide the surface of the ground into polygonal blocks. In the spring these frost cracks become filled with surface water which immediately freezes. In the expansion of the frozen ground with rise of temperature in summer the vein of ice, being more rigid than the country formation, forces readjustment to take place in the latter. The result is to bulge up the enclosed block either bodily, or else locally along the sides of the ice. During the next winter's cold wave a new crack forms at the same locus, so that a continually growing wedge of ground ice is formed. Thus the tundra becomes underlain by a network of ice wedges, which enclose bodies of the original formation. The ice wedges are constantly associated with the frost crack locus.

The above theory was independently formed during the summer of 1914, after nine summers in the field. In reviewing the literature it was found that von Bunge in 1884 had proposed a similar theory for the ground ice in Siberia. Frost cracks which divide the tundra into polygonal blocks are mentioned by several other Siberian investigators. Wedge-shaped and cylindrical earth inclusions are described and shown in photographs and drawings of the same region. Parallel ridges enclosing frost cracks and surrounding pods are also mentioned.

Polygonal surface markings underlain by ice are described in Spitzbergen, photographs of which might well serve for northern Alaska. At Eschscholtz Bay in Alaska, pot-like earth-inclusions in the ice are mentioned, as well as vertical dikes of ice and upturned muck beds. Excellent photographs taken recently upon the Noatak River, Alaska, show wedges of ice 8 to 10 feet wide, separated by from 50 to 100 feet of silt or muck.

Discussion: H. M. EAKIN said that in places in Alaska there are actual strata of buried ice of considerable horizontal extent, although the phenomena described by LEFFINGWELL often gave a false impression as to the prevalence of such strata. He thought the burial of snow-accumulations under dunes would produce such buried lenses of ice. A. H. BROOKS thought that there might be different methods by which buried wedges and strata of ice might be formed in different regions in Alaska under different climatic conditions. F. L. HESS spoke of a 30-foot mine shaft which had been sunk on one of these ice-wedges, and described similar wedges, now empty of ice but filled with peat.

C. N. FENNER, *Secretary.*

THE BOTANICAL SOCIETY OF WASHINGTON

The 100th regular meeting of the Botanical Society of Washington was held in the Crystal Dining Room of the New Ebbitt Hotel, at 6 p.m., December 1, 1914. One hundred and four members and eight guests were present. A dinner was served at which were featured several dishes made from plants which have been introduced to this country by the U. S. Department of Agriculture. Drs. W. RALPH JONES, J. S. COOLEY, H. V. HARLAN and Messrs. G. F. GRAVATT, G. H. GODFREY, L. M. HUTCHINS, PAUL POPENOE and R. G. PIERCE were unanimously elected to membership. The remainder of the evening was given to a special program dealing with the early history and growth of the Society with the following papers:

Mr. M. B. WAITE, *The Botanical Seminar and the early development of plant pathology in Washington.* The Botanical Seminar was founded in 1893. The purpose of the members was to make the meetings as informal as possible. The monthly meetings were held at the rooms of the various members. There were no officers other than the speaker of the evening who usually was the person entertaining the Seminar. There was no constitution or by-laws. Refreshments were served and very frank discussion and criticisms was encouraged. In 1901 the

number of candidates for membership became so great that this method of holding meetings became impossible and the Botanical Seminar was merged with the Washington Botanical Club to form the present Botanical Society of Washington. The speaker sketched briefly the development of the work in plant pathology in Washington from the early beginning, when the pathological work was a very small branch of the botanist's duties, up to the present large body of investigators.

Mr. DAVID FAIRCHILD, *Letters from the boys in Washington.* This consisted in the reading of actual letters from various early workers in plant pathology and physiology and brought home to those present the actual condition of things at that time more vividly than could have been done in any other way.

Dr. EDWARD L. GREENE, *The Washington Botanical Club.* The Washington Botanical Club was founded in 1898 with a very informal organization quite similar to that of the Botanical Seminar. The Botanical Club included more especially the workers in systematic botany. Dr. GREENE was the first president. In 1901 it was merged with the Botanical Seminar to form the Botanical Society of Washington.

Mr. F. V. COVILLE, *Systematic botany.* Mr. COVILLE gave briefly some of the more important features of systematic botany in Washington from the early days up to the present time, emphasizing the use of types of species, which was a direct contribution of the United States Department of Agriculture.

Mr. WALTER T. SWINGLE, *Early history of physiological and plant breeding work in the Department of Agriculture.* This briefly sketched the beginning of the now extensive work in plant pathology and plant breeding in the U. S. Department of Agriculture.

On Tuesday, January 5, 1915, at 8.30 p.m., the Botanical Society of Washington met in joint session with the Washington Academy of Sciences in the Assembly Hall of the Cosmos Club. Prof. J. C. BOSE gave an illustrated lecture on *The response of plants.*

The 101st regular meeting of the Botanical Society of Washington was held January 9, 1915, at 1.30 p.m., in the West Wing of the new Department of Agriculture building. Thirty-four members were present. Messrs. F. TRACY HUBBARD, HOWARD S. COE, LUTHER P. BYARS and Dr. L. O. KUNKEL were unanimously elected to membership. The resignation of Mr. H. C. GORE as Treasurer of the Society was accepted and Mr. C. E. LEIGHTY was elected to that office. No scientific program was presented.

PERLEY SPAULDING, *Corresponding Secretary.*

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